Miniature Radio Frequency Transceiver

This application is a continuation of application SN 09/481,807 filed 1/11/00, which is a divisional of application SN 08/934,701 filed 9/22/97, now US Patent 6,013,949; which is a continuation of application SN 08/610,236 filed 3/4/96, now abandoned; which is a continuation of application SN 08/168,909 filed 12/17/93, now US Patent 5,497,140; which is a continuation of application SN 07/928,899 filed 8/12/92, now abandoned.

TECHNICAL FIELD

This invention relates generally to electrically powered postage stamps and mailing labels which operate to transmit radio frequency (RF) identification signals to an interrogator either at the point of shipment origin, in transit, or upon reaching a point of destination. More particularly, this invention relates to such stamps and labels having an integrated circuit therein powered by a thin flat battery cell.

RELATED APPLICATION AND BACKGROUND ART

In my co-pending application Ser. No. (71-579) entitled "Radio Frequency Identification Device and Method of Manufacture, Including an Electrical Operating System and Method", filed Jun. 17, 1992, there are disclosed and claimed new and improved radio frequency identification (RFID) tags which may be affixed to various articles (or persons) so that these articles, when shipped, may be easily tracked from the point of shipment origin, then along a given route, and then readily located upon reaching a point of destination. These RFID tags are constructed within a small area on the order of one inch (1") square or less and of a thickness on the order of 30 mils. These tags include, among other things, an integrated circuit (IC) chip having transmitter, receiver, memory and control logic sections therein which together form an IC transceiver capable of being powered by either a small battery or by a capacitor charged from a remote RF source. The IC chip including the RF transmitter and receiver sections operates to provide for the RF signal transmission and reception to and from remote sources, and a thin film antenna is also constructed within the above small area. The above novel RFID system operates to receive, store, and transmit article-identifying data to and from the memory within the IC chip. This data is stored within the IC chip memory stage and may be

subsequently called up and transmitted to an interrogating party at the above point of origin, points along a given shipment route, and then upon reaching a point of destination. This co-pending application is assigned to the present assignee and is incorporated herein by reference.

The RFID device disclosed and claimed in my above identified co-pending application represents not only a fundamental breakthrough in the field of RF identification generally, but also represents significant specific advances over the prior art described in some detail in this co-pending application. This prior art includes relatively large hybrid electronic packages which have been affixed to railroad cars to reflect RF signals in order to monitor the location and movement of such cars. This prior art also includes smaller passive RFID packages which have been developed in the field of transportation and are operative for tracking automobiles. These reflective passive RFID packages operate by modulating the impedance of an antenna, but are generally inefficient in operation, require large amounts of power to operate, and have a limited data handling capability.

The above mentioned prior art still further includes bar code identification devices and optical character recognition (OCR) devices which are well known in the art. However, these bar code identification and OCR devices require labor intensive operation and tend to be not only very expensive, but highly unreliable. However, all of the above mentioned prior art devices described in my above co-pending application are only remotely related to the present invention as will become more readily apparent in the following description thereof.

SUMMARY OF INVENTION

The general purpose and principal object of the present invention is to provide still further new and useful improvements in the field of radio frequency identification (RFID) generally and improvements which are particularly adapted and well-suited for operation with electrically powered postage stamps and mailing labels. These new and useful improvements are made both with respect to the novel devices and processes described and claimed in my above identified co-pending application, and also with respect to all of the prior art described therein.

To accomplish the above purpose and object, there have been developed both an electrically powered postage stamp and an electrically powered mailing label, each of which include, in combination, an integrated circuit chip having an RF transceiver constructed therein; a thin flat battery cell connected to the IC chip for providing power thereto; and a thin film RF antenna connected to the

IC chip for transmitting data to and from the IC chip. All of the above components are connected in a very thin array and mounted between opposing major facing surfaces of either a postage stamp or a larger mailing or shipping label in a substantially two dimensional planar configuration. These components are operative to store data in the IC chip memory, which data includes such things as the destination address, return address, and descriptions of the contents of the article being mailed or shipped. These components are further operative in a novel system combination to transmit the stored data to an interrogating party upon receipt of RF interrogation signals transmitted to the stamp or label, or to receive data from same.

Accordingly, it is another object of this invention to provide a new and improved RFID stamp or label of the type described which is uniquely constructed in an essentially two dimensional configuration which is easily scalable to the two dimensional major surface area of either a postage stamp or a mailing label.

Another object of this invention is to provide a new and improved electronically powered stamp or label of the type described and process for making the stamp or label which employs certain novel, thin film fabrication techniques capable of producing device thicknesses on the order of a fraction of a millimeter. These thicknesses are typically within the range of one to five mils, thereby being extremely well suited and adapted for use with corresponding postage stamp or mailing label thickness dimensions.

A further object of this invention is to provide a new and improved electronically powered postage stamp or mailing label of the type described including RFID integrated circuitry which is operatively powered by a flat and very thin battery and imparts a high and sophisticated degree of RF communication capability to these stamps or labels without significantly increasing the overall size and volume of the stamps or labels.

The above brief summary of the invention, together with its various objects, novel features and attendant advantages, will become more readily apparent in the following description of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded perspective view of the electrically powered mailing or shipping label embodiment of the invention, including the novel radio frequency identification system mounted on the

label base member. However, it should be understood that there is no basic functional difference in the label and stamp embodiments of the invention, and that the label cover and label base members shown in FIG. 1 apply equally as well to the smaller stamp cover or stamp base members which, for sake of brevity, have not been shown in the drawings.

FIG. 2 is an enlarged perspective view of an RFID device and label or stamp package constructed in accordance with a preferred embodiment of the present invention.

FIG. 3 is a plan view showing the conductive patterns on the base and cover members used in FIG. 2, including dotted line outlines for the locations of the IC chip and batteries which form the FIG. 2 structure.

FIGS. 4A through 4D are cross sectional views taken along lines 4–4 of FIG. 3 showing the four (4) major processing steps which are used in constructing the RFID device and system array in accordance with a preferred process embodiment of the invention.

FIG. 5 is a greatly enlarged perspective view of one suitable, very thin lithium/vanadium-oxide/copper battery or cell useful in the label and stamp embodiments and perspective views shown in FIGS. 1 and 2 above.

FIG. 6 is a functional block diagram showing the major signal processing stages within the RFID integrated circuit chip described herein and shown in FIGS. 1 and 2 above. These major signal processing stages are also used within the interrogation unit (not shown) which is operative to interrogate the IC chip shown in FIGS. 1 and 2 above.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, the electrically powered, RF operative label or stamp includes a cover member 10 and a base member 12 upon which a radio frequency identification system has been constructed using thin film deposition techniques of the type described in my above identified co-pending application Ser. No. (71-579) filed Jun. 17, 1992. Functionally speaking, the RFID system 14 will include one or more thin flat battery cells 16 and 18 which are connected in series as indicated by line 20 and are both connected via line 22 to drive an integrated circuit transceiver chip 24. The IC transceiver chip 24 will preferably be connected to a dipole antenna consisting of thin film antenna strips 26 and 28, and the dipole antenna 26 and 28 is operative to both transmit RF signals from the IC chip 24 to a controller and to receive incoming RF signals from an external RF source

controller and operative to encode this data in IC chip memory in a manner more particularly described below with reference to FIG. 6. This data will typically include information on the article to which the label or stamp are affixed, such as an identification number, the sender's name, point of origin, weight, size, route, destination, and the like. In addition, the RFID system 14 may be used to automatically RF communicate with postage meters and with automatic sorting machines to thereby completely eliminate the need for human intervention for such automatic sorting, thereby greatly reducing automatic mail sorting costs while simultaneously greatly increasing the speed and accuracy of the mail sorting process.

The thin flat battery cells 16 and 18 can be made of various materials and typically include an anode, a collector, a cathode material, and a battery separator including a polymer and electrolytes of the type described below so as to not exceed a total battery thickness of 1 to 10 mils, while simultaneously being flexible and in some cases rechargeable. Furthermore, imminent commercialization of solid thin flat batteries having useful current levels at low temperatures makes the present invention commercially viable. Thus, since the IC chip 24 can also be made of thicknesses of no greater than 8 mils and since the thin film metal dipole antenna strips 26 and 28 may be held to thicknesses less than 1 to 2 mils, it is seen that the total added thickness between the label cover and base layers 10 and 12 will be negligible and not significantly affecting the bulk or the volume of the stamp or label into which the RFID system 14 is incorporated.

Referring now to FIG. 2, there is shown in a perspective view a preferred device embodiment of the present invention wherein the RFID tag includes a base support layer 30 upon which an integrated circuit chip 32 is disposed on the near end of the layer 30 and connected to a dipole antenna consisting of a pair of conductive strips 34 and 36 extending laterally from the chip 32. These conductive strips 34 and 36 will typically be screen printed on the upper surface of the base support layer 30.

A pair of rectangularly shaped batteries 38 and 40 are positioned as shown adjacent to the IC chip 32 and are also disposed on the upper surface of the base support member 30. The two rectangular batteries 38 and 40 are electrically connected in series to power the IC chip 32 in a manner more particularly described below. The device or package shown in FIG. 2 is then completed by the folding over of an outer or upper cover member 42 which is sealed to the exposed edge surface portions of the base member 30 to thereby provide an hermetically sealed and completed package.

When the cover member 42 is folded over on the base member, the contact 50 which is attached to batteries 38 and 40 using conductive epoxy, provides the back side series electrical connection for the two batteries 38 and 40. The integrated circuit chip 32 has transmitter, memory, control, logic, and receiver stages therein and is powered by the two batteries 38 and 40 during the transmission and reception of data to and from an interrogator to provide the interrogator with the various above information and identification parameters concerning the article, animal or person to which the RFID tag is attached.

Referring now to FIG. 3, there is shown a plan view of the geometry of the base support member 30 and the cover member 42 which, during the initial manufacturing stage for the RFID device, are joined at an intersecting line 44. The dipole antenna strips 34 and 36 are shown positioned on each side of the IC chip 32, and the two conductive strips 46 and 48 serve to connect the tops of the batteries 38 and 40 into the IC chip 32. A conductive strip 50 is provided on the upwardly facing inside surface of the top cover 42, so that when the cover 42 is folded by 180.degree. at intersecting line 44, its outer boundary 52 is ready to be sealed with the outer boundary 54 of the base support member 30. Simultaneously, the conductive strip 50 bonded by the conductive epoxy to the batteries 38 and 40, completes the series electrical connection used to connect the two batteries 38 and 40 in series with each other and further in the series circuit with the integrated circuit chip 32 through the two conductors 46 and 48.

Referring now to FIGS. 4A through 4D taken at the 4A–4D cross section indicated in FIG. 3, FIG. 4A shows in cross section view the IC chip 32 bonded to the base support member 30 by means of a spot or button of conductive epoxy material 56. The conductive strip 48 is shown in cross section on the upper surface of the base support member 30.

Referring now to FIG. 4B, the battery 40 is aligned in place as indicated earlier in FIG. 2 and has the right hand end thereof bonded and connected to the upper surface of the conductive strip 48 by means of a spot of conductive epoxy applied to the upper surface of the conductive strip 48, but not numbered in this figure.

Referring now to FIG. 4C, a stiffener material 58 is applied as shown over the upper and side surfaces of the IC chip 32, and the stiffener material will preferably be an insulating material such as "glob-top" epoxy to provide a desired degree of stiffness to the package and protection for the integrated circuit as completed.

Next, a spot of conductive epoxy is applied to each end of the conductive strip 50, and then the cover layer material 42 with the conductive epoxy thereon is folded over onto the batteries 38 (of FIG. 2) and 40 and the base member 30 to cure and heat seal and thus complete and seal the package in the configuration shown in FIG. 4D. This figure corresponds to the remaining stations 22, 24, and 26 in FIG. 1.

Referring now to FIG. 5, there is shown in a greatly enlarged perspective view a lithium/vanadium-oxide/copper battery including a lithium anode 60 as a top plate for the battery, an intermediate polymerized vanadium oxide electrolyte and separator layer 62 and a copper collector 64. However, the layer 62 is not limited to the use of vanadium oxide (V_2O_5 or V_6O_{13}), but may use other oxides such as magnesium oxide, MnO_2. The intermediate layer 62 is formed and polymerized on the upper surface of the copper collector 64 and may be obtained from outside manufacturers or vendors as a one piece sheet (62, 64) and then assembled in house with lithium top anode sheets. Alternatively, the thin flat battery structure shown in FIG. 5 may be obtained as a completed battery cell from outside vendors or manufacturers. The thickness of these thin flat batteries will typically be in the range of 1 to 10 mils, and as previously indicated may be made as thin as a fraction of a mil. The components are assembled in an argon or other inert dry atmosphere using state of the art thin dry cell fabrication techniques. The use of conductive polymer layers as separators in thin flat battery cells is generally known in the art and is described, for example, in an article by M. G. Kanatzibis entitled "Conductive Polymers", Chemical and Engineering News—American Chemical Society, Dec. 3, 1990, incorporated herein by reference.

Referring now to FIG. 6, the rectangular outer boundary 66 in this figure defines the active area on the integrated circuit chip (e.g. 24 in FIG. 1) in which the novel integrated circuit transceiver has been formed using state of the art MOS planar processing techniques. These MOS planar processing techniques are well known in the art and are, therefore, not described in detail herein. Within the chip active area 66 there is provided an RF receiver stage 68 and an RF transmitter stage 70, both connected through a common line or connection 72 to an off-chip antenna 74 of any planar type. A sleep/wake up circuit 76 is also connected via line 78 to the antenna 74 and operates in response to signals received from the antenna 74 to activate the necessary remaining circuitry and stages on the IC chip 66 described below.

The receiver 68 is connected through a line 80 to a control logic stage 82, and a first output line

84 from the control logic stage 82 is connected as an input to the memory stage 86. A return output line 88 from the memory stage 86 connects back to the control logic stage 82, and a second output line 90 from the control logic stage 82 connects as a second input to the transmitter 70 for providing memory or stored input data to the transmitter 70 via the control logic stage 82. In a data encoding operation, the data received concerning ID number, name, route, destination, size, weight, etc. is processed through the receiver 68 and through the control logic stage 82 and encoded into the memory stage 86.

As an example of a data call-up operation, when the RFID package in the above figures is placed on the outside surface of a piece luggage by the airlines or on a package for shipment by the postal service, either the airline agent or the postal worker will transmit information to the receiver 68 via an RF communication link concerning data such as the owner's name ID number, point of origin, weight, size, route, destination, and the like. This information received at the receiver stage 68 is then transmitted over line 80 and through the appropriate control logic stage 82 which sorts this information out in a known manner and in turn transmits the data to be stored via lines 84 into a bank of memory 86. This data is stored here in memory 86 until such time that it is desired to call up the data at one or more points along the shipment route.

For example, upon reaching a point of shipment destination, an interrogator may want to call up this data and use it at the point of destination for insuring that the item of shipment or luggage is most ensuredly and efficiently put in the hands of the desired recipient at the earliest possible time. Thus, an interrogator at the destination point will send interrogation signals to the RFID chip 66 where they will be received at the antenna 74 and first processed by a sleep/wake up circuit 76 which operates to bring the FIG. 6 circuitry out of the sleep mode and allow the receiver stage 68 to process this received data to the control logic stage 82 via line 80. At the same time, the requestor will be operating an interrogation electronic unit having therein the same circuitry as that shown in FIG. 6, less the sleep/wake up circuit 76.

With all stages in the FIG. 6 circuitry now awake, the memory stage 86 will produce the above six pieces of information relating to the shipped article and generate this data on line 88 and back through the control logic stage 82 into the transmitter 70 so that the transmitter 70 can now transmit this data to the interrogator.

The receiver and transmitter sections 68 and 70 in FIG. 6 will preferably be operated in one of the well known spread spectrum (SS) modes using one of several available SS types of modulation

which include: (1) direct sequence, (2) frequency hopping, (3) pulsed FM or chirped modulation, (4) time hopping, or time-frequency hopping used with pulse amplitude modulation, simple pulsed amplitude modulation or binary phase shift keying. The spread spectrum mode of operation per se is generally well known in the art and must conform to the frequency band separation requirements of the FCC Regulations, Part 15, incorporated herein by reference. The circuitry for the interrogation unit (not shown) will be similar to the functional system shown in FIG. 6 as will be understood by those skilled in the art, and therefore the interrogation unit will not be described herein.

Various modifications may be made in and to the above described embodiment without departing from the spirit and scope of this invention. For example, various modifications and changes may be made in the antenna configurations, battery arrangements (such as battery stacking), device materials, device fabrication steps, and the system block diagram in FIG. 6 without departing from the scope of this invention. In addition, the various off chip components such as the antenna, battery, capacitor, and even inductors can be manufactured on-chip within the claims herein. In the case where RF charging is used, a battery will not be required. Accordingly, these and other constructional modifications are within the scope of the following appended claims.

In addition, still other modifications may be made in and to the above described cell fabrication and device fabrication procedures without departing from the spirit and scope of this invention. For example, the present invention is not limited to the use of any particular types of thin flat battery cells or materials or cell fabrication processes, nor is it limited to the particular preferred fabrication technique for the RFID system as shown in FIGS. 2, 3, and 4 above. Moreover, the present invention is not strictly limited to the use of radio frequency communication and may, in environments where RF signals are not allowed, be modified so that the IC chip transceiver is capable of communicating with light waves using certain state of the art electro-optical coupling techniques which are not described herein, but are clearly within the scope of the following appended claims.

Finally, it will be understood and appreciated by those skilled in the art that the present invention also includes forming an optical detector on the IC chip as a means of receiving and detecting signals carried by light and also as a means of powering the RFID transceiver as an alternative to using a battery. Accordingly, these and other systems and constructional modifications are clearly within the scope of the broad claims filed herein.